Effects of Doping Elements on the Tribological Properties of DLC films

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1. Introduction

Diamond-like carbon (DLC) films are well known for reducing friction of interacting surfaces in relative motion. Tribological properties of DLC films are influenced by surrounding environment and its structure. It has been reported that a friction coefficient of hydrogenated DLC films had no effect on the friction reduction under the oil lubricating condition, while titanium nitride (TiN) films led to a lower friction coefficient in the same lubricating condition [1]. Therefore, in order to improve the reactivity between DLC films and lubricants, various experiments have been performed by doping several alloy elements to the DLC films [2]. However, there is still a lack of understanding of the sliding mechanisms which is changed by elements doping to DLC films.

In this research, the friction behavior of Ti-, Cr-, and Si-doped DLC films and a-C:H DLC film were investigated by using a ball-on-disk tribo-tester under oil lubricating conditions.

2. Experimental details

Four different types of DLC films were tested. In all cases, DLC films were deposited on the test specimens made of bearing steel. Friction tests were carried out using a ball-on-disk SRV tribo-tester, where a 10mm diameter bearing steel ball was loaded and rubbed against a DLC coated disc under boundary lubricating conditions (applied load = 50N, a frequency of 50 Hz, a temperature of 50 ° C with a stroke of 1.0 mm for 1 hour) . The base oil and additives used in this study were PAO (poly alpha olefin), PAO+ZnDTP (zinc dialkyl ditio phosphate) and PAO+ZnDTP/MoDTC (molybdenum ditio carbamate).

3. Result

Figure 1 shows the friction coefficient as a function of sliding time for the DLC films under PAO, PAO+ZnDTP and PAO+ZnDTP/MoDTC. From Fig. 1 (a), the friction coefficients of all DLC films showed about 0.14 at the end of the experiment. Fig. 1 (b) showed that an addition of ZnDTP to base oil demonstrated more stable than that of PAO-lubricated condition. Furthermore adding MoDTC in PAO+ZnDTP (Fig. 1 (c)) showed that the friction coefficient of all DLC films became unstable with the beginning of the experiment except Cr-DLC. The Cr-DLC film showed a low friction coefficient about 0.09 and stable friction behavior at 15000 cycles just after the experiment start.

4. References

[1] S. Miyake, et al. “Improvement of boundary lubrication properties of diamond-like carbon (DLC) films due to metal addition”, Trib. Int., 37, 2004, 751-756
[2] B.Vengudusamy, et al. “Friction properties of DLC/DLC contacts in base oil”, Trib. Int., 44, 2011, 922-932

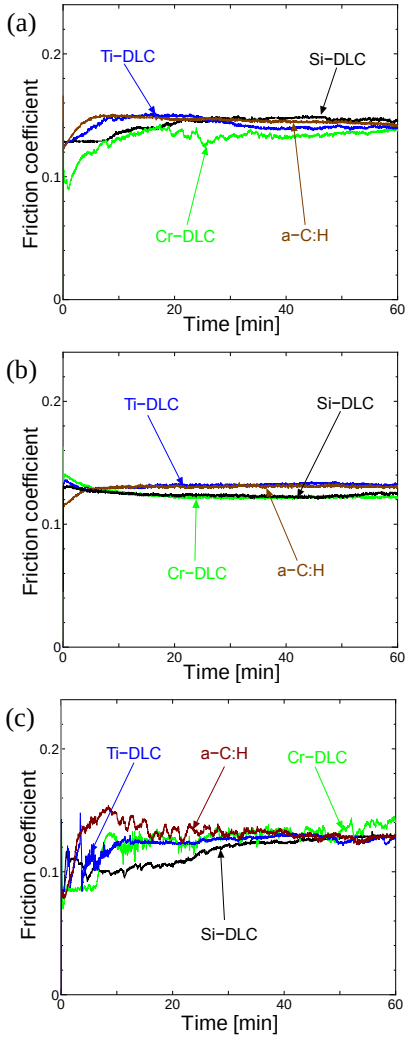

Fig.1 Friction coefficient behavior of different DLC films under (a) PAO, (b) PAO+ZnDPT and (c) PAO+ZnDPT/MoDTC